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◆COMMENTARY ◆

Chimney Grafts to Perfuse Functionally Important Inferior Mesenteric Arteries Not in a Stent-Graft Landing Zone: The Missing Clinical Relevance Is Still of Concern

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In the beginning, the use of a chimney graft was sporadic. In 2003, Roy Greenberg was the first to report the use of self-expanding stents to "raise the effective renal artery origin in conjunction with an endovascular graft."[1] Two years later, Thomas Larzon intentionally used a balloon-expandable stent to maintain perfusion through the left common carotid artery, extending the proximal landing zone for a thoracic stent-graft in a patient with aortic arch aneurysm.[2] Clinical use of chimney grafts has increased steadily since because they are readily available (using standard off-the-shelf endovascular tools and materials) and add little time to the endovascular aneurysm repair (EVAR) procedure. Moreover, there are few anatomical limitations. There are reports of high technical success rates with low mortality and morbidity. The use of these parallel grafts (chimney, periscope, or sandwich) has proven to be feasible, safe, and effective with encouraging midterm results,[3] but the indications for use of parallel grafts are not yet fully defined.

In this issue of the *JEVT*, Donas and the Münster group[4] touch upon two as yet unanswered issues in endovascular repair of abdominal aortic aneurysm (AAA): the importance of intentionally covering the inferior mesenteric artery (IMA) and the use of chimney (parallel) grafts to maintain blood flow to an IMA origin covered by an aortic stent-graft.

The mesenteric circulation has unlimited anatomical variations, with many types of collaterals between the mesenteric arteries. The celiac trunk and superior mesenteric artery (SMA) communicate through the superior and inferior pancreaticoduodenal arteries, respectively. The IMA is the smallest of the mesenteric arteries and normally supplies the distal transverse, descending, and sigmoid colon, but also the rectum. Major branches of the IMA, the left colic, sigmoid, and hemorrhoidal arteries, make collateral flow patterns between the mesenteric vessels. Apart from those major pathways between the IMA and SMA (marginal artery of Drummond, the arc of Riolan, and the meandering mesenteric artery) mentioned by Donas et al.,[4] there are other numerous non-mesenteric collaterals to the lumbar branches of the aorta, branches of the internal iliac artery, the middle sacral artery, the renal arteries, and occasionally, the celiac axis in cases of aberrant middle colic artery origin.[5] The contribution of these non-mesenteric pathways and collaterals, including the internal iliac arteries, are not well documented in the literature.

Impairment of both mesenteric and non-mesenteric pathways and collaterals might hemodynamically contribute to bowel ischemia. It is currently believed that at least two of

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three major mesenteric vessels must be occluded or critically stenosed for mesenteric ischemia to occur. In patients with both SMA and celiac trunk occlusion, exclusion of the IMA during EVAR might be dangerous. There are no data as to whether the preoperative assessment of mesenteric and non-mesenteric collaterals by computed tomographic angiography (CTA) will define the mesenteric circulation at risk for bowel ischemia.

Moreover, there are other mechanisms proposed to explain colon ischemia after EVAR. In the early post EVAR period, the cause of ischemic colitis can be atherosclerotic, thrombotic, or embolic from intraluminal manipulation during stent deployment. Hypoperfusion, low cardiac output, or sepsis may precipitate symptomatic bowel ischemia.[6] In the Donas article,[4] considering that both the SMA and celiac trunk were patent, the true indication for maintaining perfusion of the IMA during EVAR in patients with occlusion of both internal iliac arteries is intriguing and speculative. Certainly, an indication that is not related to the proximal or distal landing zone might be considered new, but in the setting described by the Münster group,[4] it is difficult to know if a chimney is necessary. Whether analysis of collateral circulation by CTA could be of any use is another question that will probably never be answered.

The first use of a parallel graft to the IMA (a periscope in this instance) was described by the Zürich group,[7] which allowed extension of the distal landing zone and complete endovascular treatment of a ruptured syphilitic thoracoabdominal aneurysm with short distal neck. In this particular patient, the celiac trunk, SMA, and left renal artery were occluded. The right pelvic kidney was regularly perfused through an aberrant right renal artery. The only arterial supply for all abdominal organs was an elongated IMA with midgrade stenosis at its origin. The rationale to maintain perfusion to this IMA was obvious, and the indication was clear.

The same concern applies to the need to obtain perfusion of any accessory renal arteries (ARA) located in the proximal landing zone during EVAR. Current evidence supports the safety of ARA coverage even though segmental renal infarction may occur in a considerable number of patients, which does not seem to be associated with renal failure or a change in hypertensive status.[8] In patients with chronic renal impairment, no differences in renal function have been observed after preservation or coverage of accessory renal arteries.[9] In patients with AAA and horseshoe kidneys, where the kidney is frequently supplied by multiple renal arteries, endovascular treatment is feasible, especially in patients with normal renal function.[10] Coverage or embolization of an aortic branch for isthmus results in decreased renal perfusion, but no renal function impairment.[11] In the endovascular era, we can push the boundaries of treatment and use chimney grafts to preserve the perfusion of renal arteries. Whether this technical ability will be of value in a functional sense, time will tell.

The technical success of the parallel graft technique lies in a standardized operating technique based on preoperative planning with CTA of the entire thoracoabdominal aorta and access vessels (iliac, femoral, axillary, and subclavian). The implantation technique used by Donas et al.[4] is known, and the authors emphasized the need to use bare stents to prevent disconnection between stent-grafts and to line them. Further advantages of bare stents to reline the stent-grafts are better visibility and prevention of compression by the aortic stent-graft that could compromise flow through the chimney graft. This is why selective angiography and pressure measurements inside any aortic and branch stent-grafts are suggested to exclude relevant endoleak(s) and/or significant pressure gradient(s) that should be corrected immediately by using bare metal stents.[12] The latter is of less importance in chimneys with antegrade flow, but of more importance in a periscope graft where perfusion is in the retrograde direction.

The article by the Münster group[4] shows the versatility of using a chimney stent-graft to address an aortic branch that is assumed to be functionally important rather than being involved in the proximal or distal landing zone. The indication is, as presented by the authors, rather arbitrary. Furthermore, this use shows that the chimney technique is not

a bailout, but a preoperatively planned procedure to maintain the perfusion of an artery.

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